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SECTION I.—AEROLOGY.

SOLAR AND SKY RADIATION MEASUREMENTS DURING JANUARY, 1917.

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[Dated: Washington, D. C., Feb. 27, 1917.]

INSTRUMENTS AND EXPOSURES.

In this REVIEW for January, 1916, 44:2, will be found descriptions of the exposure of the Marvin pyrheliometer at the various stations, and an account of the method of obtaining and reducing the radiation measurements. These still apply, except that at Santa Fe, N. Mex., the pyrheliometer is now installed in a shelter on the roof of the office building, at an elevation of 7,037 feet (2,145 meters), above sealevel, where exposure to the sun is possible at all hours of the day.[1]

On page 3 of the same number of the REVIEW will be found a description of the exposure of the Pickering polarimeter at Washington, D. C., and of the point in the sky where measurements of the percentage of polarization of skylight are made. A polarimeter of the Pickering type is also installed at Madison, Wis., on the roof of North Hall of the University of Wisconsin. It is about 20 feet north of the thermometer shelter on which the Callendar pyrheliometer is located (see below), and about 10 feet lower than the latter. The proximity of Lake Mendota to North Hall may slightly reduce the skylight polarization measurements at this point in Summer. Since measurements are not made when the ground is covered with snow, very few measurements will be obtained at Madison during the winter season.

In this REVIEW for January and April, 1916, 44:4, 179–180, will be found descriptions of the exposure of the Callendar recording pyrheliometer at the different stations, and an account of the method by which the records are reduced to heat units. Since the burning of University Hall at Madison, Wis., on October 10, 1916, the dome of that building no longer shades the Callendar pyrheliometer at any season of the year.

RADIATION NORMALS.

The monthly normals from which are computed the departures of Table 1, are revised each month to include the current measurements. The series of measurements at Madison and Santa Fe from which these normals are computed include readings obtained during the years 1912 and 1913, which were abnormally low on account of the dusty condition of the atmosphere following the eruption of Katmai volcano in Alaska in June, 1912. The series at Lincoln and Washington do not include these years. In consequence, the probability of the occurrence of plus departures of radiation intensities in Table 1 is greater at Madison and Santa Fe than at Washington and Lincoln. The daily normals of radiation of Table 3 ("Daily total" + "Departure from normal"), are also recomputed to include the current daily totals of each month.

SOLAR CONSTANT DETERMINATIONS.

Whenever the Marvin pyrheliometer measurements indicate a sufficiently constant value of the atmospheric transmission coefficient throughout a half-day period, the readings are extrapolated to air mass 1 (zenithal sun), and also to air mass 0 (outer limit of the atmosphere). From this latter value, in connection with the water vapor pressures of Table 2, the value of the solar constant is computed by the Smithsonian "Abridged procedure for determining approximately the value of the solar constant."[2] The method is described and illustrated in the REVIEW for September, 1915, 43:440–441.

OBSERVATIONS.

Table 1 is a summary of the measurements that have been made at the different stations during January, 1917, with the Marvin pyrheliometer. The departures from normal values indicate that direct solar radiation intensities were about normal at Madison and Lincoln, slightly above normal at Santa Fe, and slightly below normal at Washington. At Lincoln a noon intensity of 1.56 calories obtained on the 13th exceeds by about 2 per cent the maximum noon intensity of January, 1916. At Santa Fe the noon intensity of 1.66 calories, measured on the same day, equals any previous intensity measured at that station.

Skylight polarization measurements made at Washington on 6 days give a mean of 61 per cent and a maximum of 66 per cent on three different days. This latter is slightly less than the average January maximum for Washington.

Table 3 shows less than the normal amount of radiation for the month at Washington and Lincoln, and more than the normal amount at Madison.

On the afternoon of January 5, at Madison, and on the mornings of January 8, 25, and 27, at Santa Fe, the measurements with the Marvin pyrheliometer indicate quite steady sky conditions with respect to the transmission of solar radiation. Extrapolation of the readings to air mass 1 and air mass 0 gives the results tabulated in Table 4.

[1] This REVIEW, May, 1916, 44:244.

[2] *Astrophysical Observatory of the Smithsonian Institution.* Annals, 1908, 2:115.

TABLE 1.—*Solar radiation intensities during January, 1917.*

[Gram-calories per minute per square centimeter of normal surface.]

Washington, D. C.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Jan. 2			1.17	1.05	0.97	0.83				
6			1.19	0.98	0.87	0.75	0.67	0.62	0.58	0.55
11			1.12							
12			1.16	1.03	0.93	0.81	0.70	0.62	0.58	0.50
17			0.98							
18			1.17	1.08	0.89	0.80	0.75	0.69	0.62	0.57
19			1.30	1.16	1.06	1.00	0.94	0.88	0.82	
26			1.08		0.94	0.86				
30			1.14	1.07	0.90	0.76	0.68	0.62	0.58	0.54
Monthly means			1.15	1.06	0.94	0.83	0.75	0.69	0.64	0.54
Departure from 9-year normal			−0.05	−0.02	−0.05	−0.09	−0.12	−0.10	−0.09	−0.13
P. M.										
Jan. 2				1.00						
6				0.95	0.85	0.74	0.65	0.58	0.51	
8			1.36	1.26	1.15	1.04	0.95	0.90	0.86	
12				1.05						
19				1.14	1.02	0.92				
26			1.19	1.14	1.00	0.93	0.86	0.78		
28			1.27		1.09	0.98	0.88	0.81	0.79	0.76
30			1.24	1.16		1.02	0.96			
Monthly means			1.26	1.10	1.02	0.94	0.86	0.77	0.72	(0.76)
Departure from 9-year normal			+0.03	−0.02	−0.02	±0.00	−0.02	−0.05	−0.05	+0.02

Madison, Wis.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Jan. 5				1.39	1.29	1.21				
8						1.12	1.05	0.99	0.93	0.87
9										1.00
11				1.43			1.14			
16				1.37		1.18				
18				1.39		1.18				
20			1.50	1.36	1.24					
22				1.37						
24			1.30	1.27	1.23	1.17	1.09	1.04	0.99	
Monthly means			(1.40)	1.37	1.25	1.17	1.09	(1.02)	(0.96)	(0.94)
Departure from 7-year normal			+0.05	+0.01	−0.02	−0.01	+0.01	+0.03	+0.07	−0.02
P. M.										
Jan. 5				1.39	1.31	1.25	1.18			
22				1.35	1.33					1.30
23					1.07					
24				1.24	1.11					
25					1.25	1.22				
29				1.24	1.17	1.10	1.03			
Monthly means				1.30	1.21	1.19	(1.10)			(1.30)
Departure from 7-year normal				−0.02	−0.03	+0.01	−0.02			

TABLE 1.—*Solar radiation intensities during January, 1917*—Contd.

[Gram-calories per minute per square centimeter of normal surface.]

Lincoln, Nebr.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Jan. 2				1.17						
3			1.31							
5				1.43	1.38	1.32	1.22	1.13	1.07	
8			1.52	1.41	1.21	1.14	1.04			0.90
13			1.59	1.47	1.40	1.34	1.27	1.17	1.11	1.04
18					1.34	1.28	1.18			
19				1.39	1.31	1.24	1.18		0.82	
24			1.16							
26				1.22	1.07	0.96	0.90	0.87	0.85	
28			1.39							
29			1.41							
30			1.36	1.22	1.13					
Monthly means			1.39	1.33	1.26	1.21	1.13	1.06	0.96	(0.97)
Departure from 2-year normal			−0.03	−0.01	±0.00	+0.01	+0.01	+0.02	−0.02	
P. M.										
Jan. 3				1.22	1.20					
5				1.39	1.31	1.30	1.20	1.14	1.08	
8				1.35						
13				1.52	1.39	1.32	1.26	1.20	1.13	1.07
29				1.30	1.19	1.13			0.96	
Monthly means				1.36	1.27	1.25	1.23	1.17	1.06	(1.07
Departure from 2-year normal				±0.00	+0.02	+0.01	+0.06	+0.07	−0.03	+0.01

Santa Fe, N. Mex.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Jan. 5			1.57	1.54	1.48	1.41				
8			1.50	1.44	1.37	1.32	1.27	1.22		
9							1.38	1.31		
11			1.51	1.48	1.45	1.39	1.33			
13			1.64	1.51	1.39	1.29	1.26			
23		1.64	1.57	1.50						
24			1.60	1.52		1.38	1.29			
25		1.60	1.52	1.46	1.39	1.32	1.26			
27		1.65	1.59	1.55	1.49	1.43	1.40			
29		1.64	1.53	1.43	1.36	1.30	1.24			
Monthly means		1.63	1.56	1.49	1.42	1.36	1.30	1.26		
Departure from 5-year normal		+0.07	+0.05	+0.05	+0.01	+0.01	+0.02	+0.08		
P. M.										
Jan. 5			1.57	1.49	1.41	1.36	1.31	1.23	1.20	1.15
13				1.49	1.42	1.35				
25			1.44						1.14	
27				1.49	1.43	1.37	1.33			
29			1.50	1.43	1.37	1.31	1.26	1.21		
Monthly means			1.50	1.48	1.41	1.35	1.30	(1.22)	(1.17)	(1.15)

TABLE 2.—*Vapor pressures at pyrheliometric stations on days when solar radiation intensities were measured.*

Washington, D. C.			Madison, Wis.			Lincoln, Nebr.			Santa Fe, N. Mex.		
Date.	8 a.m.	8 p.m.	Date.	8 a.m.	8 p. m	Date.	8 a.m.	8 p.m.	Date.	8 a.m.	8 p.m.
1917.	*mm.*	*mm.*	1917.	*mm.*	*mm.*	1917.	*mm.*	*mm.*	1917.	*mm.*	*mm.*
Jan. 2	3.63	4.37	Jan. 5	2.26	1.37	Jan. 2	2.26	3.45	Jan. 5	1.60	1.88
6	3.00	2.87	8	2.16	3.45	3	2.26	3.30	8	2.26	3.00
8	2.74	2.74	9	3.63	4.37	5	2.26	3.63	9	2.36	3.45
11	2.36	1.19	11	0.48	0.56	8	2.87	3.81	11	1.96	1.96
12	1.12	1.19	16	0.46	0.64	13	0.66	0.97	13	1.37	0.71
17	2.16	3.81	18	1.68	1.12	18	2.16	2.74	23	1.07	2.06
18	3.15	3.15	20	1.68	1.78	19	1.88	2.87	24	1.60	1.45
19	1.60	1.88	22	0.97	0.71	24	1.52	2.74	25	1.24	1.78
26	2.26	1.45	23	0.51	1.88	26	1.78	2.62	27	1.78	1.96
28	2.87	4.75	24	1.24	1.19	28	3.99	4.95	29	1.96	2.26
30	4.75	2.62	25	0.66	0.79	29	3.63	3.15			
			29	4.75	3.00	30	2.49	3.30			

TABLE 3.—*Daily totals and departures of solar and sky radiation during January, 1917.*

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily totals.			Departures from normal.			Excess or deficiency since first of month.		
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.
1917.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Jan. 1	99	207	211	−62	63	30	−62	63	30
2	218	193	186	57	48	4	−5	111	34
3	56	179	189	−105	33	6	−110	144	40
4	65	117	142	−96	−30	−42	−206	114	−2
5	19	217	220	−142	69	35	−348	183	33
6	220	187	180	58	37	−7	−290	220	26
7	138	212	170	−25	61	−18	−315	281	8
8	230	200	207	66	47	18	−249	328	26
9	109	178	174	−56	24	−17	−305	352	9
10	55	135	154	−111	−21	−38	−416	331	−29
11	206	230	192	39	73	−2	−377	404	−31
12	247	80	210	79	−79	15	−298	325	−16
13	61	260	256	−108	100	59	−406	425	43
14	198	262	200	28	100	1	−378	525	44
15	63	237	176	−108	73	−25	−486	598	19
16	170	239	172	−3	73	−32	−489	671	−13
17	220	220	172	46	52	−34	−443	723	−47
18	244	250	254	68	80	45	−375	803	−2
19	278	172	236	101	−1	24	−274	802	22
20	202	228	124	23	53	−91	−251	855	−69
Decade departure							165	524	−40
21	24	24	140	−156	−153	−78	−407	702	−147
22	114	260	252	−68	81	31	−475	783	−116
23	263	277	252	79	96	28	−396	879	−88
24	77	271	238	−109	87	11	−505	966	−77
25	203	253	150	15	67	−80	−490	1,033	−157
26	262	165	157	71	−24	−77	−419	1,009	−234
27	149	179	251	−44	−12	14	−463	997	−220
28	298	218	266	102	24	25	−361	1,021	−195
29	30	251	247	−168	54	3	−529	1,075	−192
30	284	188	264	83	−12	16	−446	1,063	−176
31	117	17	227	−86	−185	−24	−532	878	−200
Decade departure							−281	23	−131
Excess or deficiency since first of year. (calories)							−532	878	−200
Excess or deficiency since first of year. (Per cent)							−9.8	16.8	−3.1

TABLE 4.—*Solar radiation intensities for zenithal sun, reduced to mean solar distance of the earth, and approximate values of the solar constant.*

[Gram-calories per minute per square centimeter of normal surface.]

Station.	Date.	Radiation intensity.		Solar constant.
		m=1	m=0	
	1917.	*calories.*	*calories.*	*calories.*
Madison, Wis.	Jan. 5, p. m.	1.60	1.79	1.87
Santa Fe, N. Mex.	Jan. 8, a. m.	1.59	1.73	1.82
	25, a. m.	1.63	1.79	1.87
	27, a. m.	1.66	1.77	1.85

A MEASUREMENT OF THE EFFECT OF CITY SMOKE.

January 5, 1917, was an unusually clear day at Lincoln, except that from the State university farm a heavy cloud of smoke was visible to the southwest over the city. The wind was about 6 miles per hour from the west or northwest until about noon, when it shifted to southwest, bringing the smoke directly over the university farm. As a result the direct solar radiation intensity dropped from 1.43 calories at 10:35 a. m., apparent time, with air mass 2.5, to 1.17 calories at 11:45 a. m., with air mass 2.23. By 1:25 p. m., the wind had gone to the south, the smoke cloud had passed away, and the intensity of direct solar radiation with air mass 2.5 had increased to 1.39 calories. From the Callendar pyrheliometer record we find that the radiation received on a horizontal surface from the sun and sky dropped from a rate of 0.67 calory per minute at 11:40 a. m. to 0.49 calory per minute at 12:10 p. m., a falling off of more than one-fourth, and returned to 0.66 calory at 1 p. m.

At the Weather Bureau office in Lincoln, where the smoke cloud was probably at about its maximum density, it was not noticed that the sky on this day presented any unusual appearance. At the State university farm the observer noticed the approach of the smoke cloud, and its passage over his station. He states that it gave the sky "a hazy or dirty appearance for a short time." From the above description it would seem that this was nothing more than the usual smoke cloud that is to be found over any city of moderate size where soft coal is burned on a day with light wind.

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NOTES ON THE HORIZONTAL RAINBOW.[1]

By SAEMONTARÔ NAKAMURA.

I pointed out in my last paper that the horizontal rainbow is due to water drops on a water surface, but I could not find the reason why water drops can float on a water surface.

It was my desire to explain how water drops are supported on a water surface. Unexpectedly I saw, one morning, the drops of water floating on a small pool in the garden of my house. The pool is so small—diameter is about 2 meters—that I had never expected to find any rainbow on it. In this pool actually I observed a rainbow and found out how the drops are supported.[2]

I found fine soot dust floating on the water and dewdrops were resting on the soot particles. Looking along the water surface I also perceived the water drops and their images in the water surface. It seemed to me that the distance between a water drop and its reflected image might be 1/100 mm. or so; the diameter of a drop lies between 1/10 mm. and 1.0 mm.

The observation was made on the morning of December 13, 1916, and at the time the water temperature was 4°C. while the vertical temperature distribution above the pool was as follows:

Altitude	100 cm.	50 cm.	10 cm.	2 cm.
Air temperature	7.2° C.	6.2°	5.6°	4.9°

The horizontal rainbow which occasionally appears in Tokyo may be explained as may be the rainbow seen this day in this pool. If there were rainfall or wind, such fine dust would be cleared away and no horizontal rainbows would be produced.

[1] *Reprinted from* Journal of the Meterological Society of Japan, Jan. 1917, 36: 1.

[2] See in this connection:
Juday, C. Horizontal rainbows on Lake Mendota, this REVIEW, Feb., 1916, 44:66 and 67.—C. A., jr.